The Geological Politics of Water Resources in the Western United States

An Undergraduate Senior Thesis

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by

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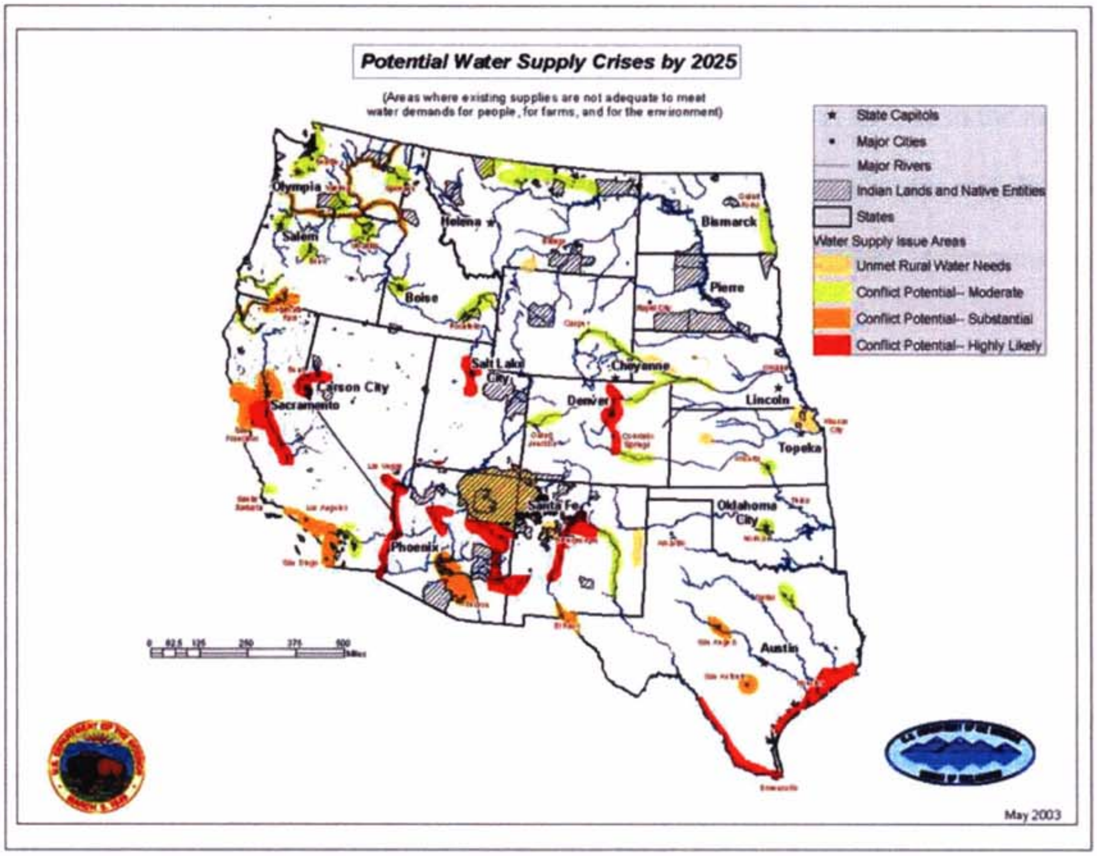
1. INTRODUCTION: LAYING OUT THE PROBLEM

Wallace Stegner, a western writer, once said, “Water is the true wealth in a dry land.” A recent article in the New York Time contained this headline, “For Texas Now, Water, Not Oil, Is Liquid Gold.” Dian Raines Ward, a conservationist who does most of her work in India, has identified water as a more important resource than oil. Political Leaders in the Middle East also claim water is worth more to their countries than oil. Dr. Halfdan Mahler, Director General of the World Health Organization, writes that he is “utterly convinced that the number of water taps per 1,000 population will be an infinitely more meaningful health indicator [of society] than the number of hospital beds per 1,000 population." This makes sense considering water is very necessary to human life, and that fact is reinforced by the fact that humans take in over 16,000 gallons of water during their lifetimes, with an average of 2.5 quarts per day (Skillings, 1999). Water carries out life processes in everything, carrying out biological reactions and aiding with digestion of other nutrients. We are beginning to see more and more evidence of global concern for a resource that most of society typically takes for granted—water. Scholars have come to the conclusion that if present consumption patterns continue, two out of every three persons on Earth will live in water-stressed conditions by the year 2025 (United Nations Environment Program). The following graphic shows the potential water crisis areas in the United States by the year 2025. See figure 1.

Figure 1.


Potential Water Supply Crises by 2025
(Areas where existing supplies are not adequate to meet water demands for people, for farms, and for the environment)
State Capitols
Major Cities
Major Rivers
Indian Lands and Native Entities
States
Water Supply Issue Areas
Unmet Rural Water Needs
Conflict Potential-- Moderate
Conflict Potential-- Substantial
Conflict Potential-- Highly Likely
Olympia
Salem
Helena
Bismarck
Boise
Pierre
Salt Lake City
Cheyenne
Carson City
Sacramento
Denver
Lincoln
Topeka
Phoenix
Santa Fe
Oklahoma City
Austin
May 2003

But this can be easily overlooked considering water resources seem to be very plentiful to some. In some regions of the world sprawling lakes, gorgeous rivers and waterfalls, vast oceans, green forests and pastures that pepper the landscape all lead to thinking that the world's supply of water is everlasting, and renewable. Droughts occur, but land is quickly revitalized in the next torrential downpour. Hundreds of breathtaking golf courses can be developed in the middle of bone dry deserts by pumping up some groundwater and mammoth farms are sustained in the same fashion. What then can possibly be the problem?

As the world population continues to grow at an uncontrollable rate, society must find a way to make water conservation more of a world priority. The facts alone should make even the most naïve person concerned. During the 20th century, water use increased at double the rate of population growth; while the global population tripled, water use per capita increased by six times. The overall amount of water on our planet has remained the same for two billion years, so for the 250 million U.S. residents living today have access to about the same amount of water as U.S. residents did 200 years ago, when the population was four million (National Drinking Water Alliance). Water covers nearly three-fourths of the earth's surface and of this most is permanently frozen or salty. The earth's total allotment of water has a volume of about 344 million cubic miles and of this: 315 million cubic miles (93%) is sea water; 9 million cubic miles (2.5%) is in aquifers deep below the earth's surface. 7 million cubic miles (2%) is frozen in polar ice caps; 53,000 cubic miles of water pass through the planet's lakes and streams; 4,000 cubic miles of water is atmospheric moisture and 3,400 cubic miles of water are locked within the bodies of living organisms (NPS Web Site). On a global average of most freshwater withdrawals, 69%, are used for agriculture, while industry accounts for 23% and municipal use (drinking water, bathing and cleaning, and watering plants and grass) just 8%. If the entire world's water were fit into a gallon jug, the fresh water available for us to use would equal only about one tablespoon.

The entire planet is currently suffering from a shortage of water. The Middle East for example is home to 5% percent of the world's population, yet only 1% of its potable water (Ward, 2001). Oil-rich but water-poor Saudi Arabia purchases half of its water abroad. Israel imports 87 percent of its water and Jordan imports 91 percent. Some 31 countries--most in the Middle East and Africa--are now listed as "water-stressed." In another 25 years, 48 countries with more than one third of the world's population will suffer from water starvation (Smith, 2000).

The United States on the other hand consumes water at twice the rate of other industrialized nations. Water use in the United States alone leaped from 330 million gallons per day in 1980 to 408 million gallons per day in 1990, despite a decade of improvements in water-saving technology. For example, there are 1.2 billion people worldwide that do not have access to clean water. The United States, however, uses 6.8 billion gallons every day just to flush their toilets. In addition, eighty percent of the fresh water we use in the U.S. is for irrigating crops and generating hydroelectric and thermoelectric-power (NSP Web Site, 1997). Specifically, in the western United States much of the water is used for agriculture. Irrigation brings cotton to Arizona, potatoes to Idaho, tomatoes to California—crops that would be unavailable to these regions in an ordinary, non-irrigated setting. About 40 percent of US water withdrawals are spent on irrigation; in some areas, more than 90 percent. Though it is seen mainly in the West, a growing number of southeastern farmers are turning to irrigation to increase yields and fight drought. Ironically, irrigated lands are disproportionately productive: Only about 5 percent of US farmlands are irrigated, but they produce 20 percent of the value of farm products. Large governmental subsidies have encouraged irrigated farming since the early 1900's. More recently, water shortages, decreased subsidies, and rising costs of pumping water have pushed farmers to adopt more efficient irrigation practices--thus curbing western water use yet that has not helped the decreased western availability of water. Farm animals and aquaculture account for only a small proportion, about 3 percent, of agricultural water use. Since 1980 a growing fish farm industry has doubled demand, traditionally limited to livestock (National Geographic Website). So the end result of a slightly more efficient irrigation practice is cancelled out by increased fish farming and livestock.

It is obvious then that fresh water is essential for human survival, for agriculture and for the survival of our planet's plants and animals. But pollution, climate change, water-related disease, and the destruction of our natural world all threaten the purity and availability of our most precious resource. Despite the pressing nature of these threats, water institutions and policymakers have, so far, been largely unable to develop the tools and approaches needed to address these problems. "The best way to solve emerging threats to the world's fresh water is by rethinking how we use and manage our scarce resources," writes Dr. Peter H. Gleick, President of the Pacific Institute. "We must look at ways to increase our efficiency of use, instead of just building more dams and reservoirs. Improving the efficiency of our water systems, taking real steps to tackle global warming, and opening the policy debate over water to new voices can help turn the tide."

Not only is irrigation sucking the land dry of water, but combined with that, society must also be concerned with global warming. New simulations by a group of leading global warming and climate change researchers suggest the effects of rising temperatures will exacerbate problems we are beginning to see. In the West, the effects of global warming already have begun to emerge in earlier melting of mountain snow packs and spring flooding dates. Scientific studies show that these, and other expected climate changes, could have a devastating impact on water resources in some parts of the West over the next half century. For instance:

- In the Columbia River System of Washington State, residents and industries likely will be faced with the choice of water for summer and fall hydroelectric power or spring and summer releases for salmon runs, but not both. Accelerated Climate Prediction Initiative research, or

ACPI, shows that with climate change, the river cannot be managed to accommodate both. In fact, the window for successful salmon reproduction in the Pacific Northwest may become so compressed by climate change that some species could cease to exist regardless of any current or future water policies.

- The Colorado River Reservoir System will not be able to meet all of the demands placed on it - including water supply for Southern California and the inland Southwest - because reservoir levels will be reduced by more than one-third and releases by as much as 17 percent. The greatest effects will be on lower Colorado River Basin states. All users of Colorado River hydroelectric power will be affected by lower reservoir levels and flows, which will result in reductions in hydropower generation by as much as 40 percent.
- In the Central Valley of California, it will be impossible to meet current water system performance levels so that impacts will be felt in reduced reliability of water supply deliveries, hydropower production and in stream flows. With less fresh water available, the Sacramento Delta could experience a dramatic increase in salinity and subsequent ecosystem disruption (NASA Earth Observatory, 2002).

The Albuquerque Tribune reported a recent study that involved more than two dozen scientists and engineers, from institutions including Scripps, the University of Washington, the Energy Department and the U.S. Geological Survey, tried to predict the impact of climate on the western water supply. They discovered a dismal future for the west.

To create the forecasts, scientists began two years ago with observations of the state of the world's oceans - those vast reservoirs of heat that drive climate - and worked to translate that into real effects on precipitation and temperature in the Columbia, Sacramento and Colorado River basins. Among the findings of what is forecast to occur in the next 25 to 50 years:

- Reservoir levels along the Colorado River will drop by more than a third and releases by 17 percent. The lower levels and flows will cut hydropower generation by as much as 40 percent.
- The Sacramento River will see reduced reliability in the volumes of water available for irrigation, cities and hydropower. With less fresh water, the Sacramento Delta will increase in salinity, disrupting the ecosystem.
- On the Columbia River system, there will be water in the summer and fall to generate electricity, or in the spring and summer for salmon runs - but not both.

Other scenarios that gauge the impact of even moderate global-scale warming on the West suggest the effects could be two to three times worse - or of the same magnitude but occurring sooner - than the newer estimates, Barnett said.

Bill Patzert a researcher from NASA claims, as many others already have, that the continued growth in the population of the West will also exacerbate the problem. Patzert also said that the problem is not simply climate change, but too many people using too much water (Bridges, 2002).

In California, the 2003 update to the state water plan, which is a document that forecasts water supplies, will include for the first time consideration of the impact of climate change. The plan, updated every five years, has not typically been tempered by changes in supply. In other words, none of the architects of this plan thought the supply of water would ever fluctuate. Because of this, California is exploring continued expansion on its network of dams, adding storage capacity to catch runoff. As an example of the short term thinking of most people involved in water projects, Pierre Stephens a lead water supply "forecaster" for the Department of California Water Resources stated that California's infrastructure was designed with the current climate in mind, not a different one, so that creates problems (Bridges, 2002).

So the Western United States is facing a real catastrophe in the next twenty-five years. We may be running out of water in response to increased population, climate change, and conservation issues. There are literally hundred of foundations, agencies and other organizations focused on fixing this problem. Meetings such as the Arbor Day Farm Conference publish documents like the *Sustainability of Energy and Water through the 21st Century*. Websites are available by the hundreds, educating children and adults on how to conserve water. Policy makers like Secretary of the Interior Gale Norton talk about policy changes and government intervention to curb the problem and save water--specifically, after hosting the Water 2025 conference which talked about finding a solution. The conference aimed to: facilitate a more forward looking focus on water started areas of the country; help to stretch or increase water supplies to satisfy the demands of growing of populations, protect environmental needs; provide added environmental support to watersheds, rivers and streams; minimize water crises in critical watersheds by improving the environment and addressing the effects of drought on important economies; and, provide a balanced, practical approach to water management for the next century (Water 2025 Web Site). A very tall order and considering the audience of people involved in this conference: farmers, water users, environmental interests, state and local governments, and recreationists, it seems a reality. Yet, with all the available facts and figures and geological evidence of the water supply running out, we still have a problem that no one is taking the necessary steps to fix.

2. A WESTERN WATER HISTORY

This problem has a long complicated history that may give some credence as to why nothing is currently happening. In response to Horace Greeley's call to America of "Go West, Young Man" We have seen the practice of human naïveté in regards to the environment and specifically water usage. Irrigation, however, started slightly earlier in Utah.

The Utah pioneers in the late 1840's were the first Anglo-Saxons to practice irrigation on an extensive scale in the United States. Being a desert, Utah contained much more cultivable land than could be watered from the incoming mountain streams. The principle was established that those who first made beneficial use of water should be entitled to continued use in preference to those who came later. This fundamental principal was later sanctioned and is known as the Doctrine of Prior Appropriation. This means those with earliest priority dates who have continuously used the water since that time have the right to water from a certain source before others with later priority dates.

In the early Territorial days, rights to the use of public streams of water were acquired by actual diversion and application of water to beneficial use, or by legislative grant. County courts water legislation was enacted in 1852, and was in effect until 1880, when it was replaced by a statute for the provision for county water commissioners.

The Utah State Engineer's Office was created in 1897. The State Engineer is the chief water rights administrative officer. A complete "water code" was enacted in 1903 and was revised and reenacted in 1919. This law, with succeeding complete reenactments of State statutes, and, as amended, is presently in force mostly as Utah Code, Title 73. In 1963 the name was changed to the Division of Water Rights, but the public sometimes still refers to the division as the State Engineer's Office.

All waters in Utah are public property. A water right is a right to the use of water based upon 1) quantity, 2) source 3) priority date, 4) nature of use, 5) point of diversion and 6) physically putting water to beneficial use (Utah Water Rights Web Site).

Prior Allocation can also be summarized as first in time, first in right, and was developed by gold miners in California as a means of distributing water on federal land in the absence of any private land titles (Sax et al., 1991). In California, Prior to 1872, appropriative water rights could be acquired by simply taking and beneficially using water. Beneficially using water could obviously have many different interpretations because a geologist or hydrologist never really defined the meaning. Politicians thought that any water not flowing in rivers and going to oceans was being used beneficially. The priority of the right was the first substantial act leading toward putting the water to beneficial use provided the appropriation was completed with reasonable diligence; otherwise, priority did not attach until beneficial use of the water commenced.

In 1872, sections 1410 through 1422 of the California Civil Code were enacted. These sections established a permissive procedure for perfecting an appropriation of water. Provisions were made for establishing a priority of right by posting a notice of appropriation at the proposed point of diversion and recording a copy of the notice with the respective County Recorder. If these procedures were not followed, the pre-1914 appropriative right did not attach until water was beneficially used (California State Water Resources Control Board Web Site).

The problems of Prior Allocation are apparent across the Southwestern US as urban areas struggle for water supplies for exploding populations while historic farms and ranges are profligate in their usage. These rules were so loose that it was obvious every single person who took advantage of Prior Allocation would have his or her own interpretation of what he or she could do with the water.

Inadequate precipitation in the American West required settlers to use irrigation for agriculture. At first, settlers simply diverted water from streams, but in many areas demand outstripped supply. As demand for water increased, settlers wanted to store "wasted" runoff from rains and snow for later use, thus maximizing use by making more water available in drier seasons. Man wanted to control flood waters in order to help create fertile farm land in dry areas. As more people found out about this land potential more and more people wanted to move west. The next problem was that everyone wanted electricity. Not only could controlling water create fertile land, but it was also known that dams could generate hydroelectric power. Currently, The US uses more water to produce electricity than for any other purpose. Electricity heats and cools buildings, drives trains, melts metals. Water helps generate power through two different processes, thermoelectric and hydroelectric. Thermoelectric plants, which convert water into steam by heating it with fossil or nuclear fuels, provide nearly 90 percent of US electric power. Though the plants guzzle 131 billion gallons of water each day, only 3 percent of that is actually consumed; the remainder is poured back into lakes and rivers. Though never leaving the stream and thus not considered a "withdrawal," far more water is needed for hydroelectric power, which provides roughly 10 percent of US electricity (National Geographic Web). Cities like Los Angeles and San Francisco grew in population which caused them to create storage for water like reservoirs and water supply systems. At that time, private and state-sponsored storage and irrigation ventures were pursued but often failed because of lack of money and/or lack of engineering skill. In 1901 a diversion channel was created to capture some Colorado River flow to irrigate the Imperial Valley (formerly known as "Valley of the Dead") It helped, but didn't provide nearly enough water to satisfy the growing population. In 1904 the Imperial Valley diversion channel kept silting up because no one involved in the initial construction consulted geologists, soil scientists, or other people who may have known this was going to happen. So, instead of figuring out why this was occurring, another temporary diversion channel was constructed just below the U.S. border. Ironically, spring floods arrived earlier than expected and the Colorado and other rivers, fueled by higher than usual water made their own new courses. Their flows went into the Alamo River which filled the Salton Sink to create the Salton Sea, or, a cesspool that would eventually dry up and form the Salton Sink again when the precipitation changed. It would flip flop like this for many years until the Colorado was virtually sucked dry.

In the late 1890s and early 1900s, an intense amount of pressure mounted for the Federal Government to undertake storage and irrigation projects. Congress had already invested in America's infrastructure through subsidies to roads, river navigation, harbors, canals, and railroads but Westerners wanted the Federal Government to also invest in irrigation projects in the West.

Irrigation projects were known as reclamation projects. The concept was that irrigation would "reclaim" arid lands for human use. In addition, "homemaking" was a key argument for supporters of reclamation because the point would be to encourage Western Settlement. President Theodore Roosevelt supported the reclamation movement because of his personal experience in the West, and because he believed in "homemaking."

In 1900 irrigation and water issues came to the forefront of politics when political candidates began incorporating water ideas in their platforms. Both Democrats and Republicans took advantage of this hot issue. Then candidate Theodore Roosevelt had a real advantage talking about water because of his deep and well known interest in natural resources and the environment. His only flaw was that he thought any water in a river flowing freely was being wasted. Water Politics became a huge issue in Washington because of an Eastern and Midwestern opposition to spending millions of dollars for people in the west who were moving into a desert. Eventually, Congress passed the Reclamation Act of June 17, 1902.

In July of 1902, in accordance with the Reclamation Act, Secretary of the Interior Ethan Allen Hitchcock established the United States Reclamation Service within the U. S. Geological Survey (USGS). The new Reclamation Service studied potential water development projects in each western state with Federal lands -- revenue from sale of Federal lands was the initial source of the program's funding.

From 1902 to 1907, Reclamation began about 30 projects in Western states. During this same time, people like William Mulholland, chief engineer of the Los Angeles water department, were trying to help out dry areas like Los Angeles, a young city, held back from becoming a metropolis because of a lack of water. Located in a semi-desert region, it required more than the Los Angeles River, to sustain its growing population and expanding industries. In 1904, William

Mulholland, proposed bringing water by aqueduct across the Mojave Desert from the Sierra Nevada range, and by 1908 the project was underway-- following some questionable political and financial maneuverings by civic leaders. In just five years, Mulholland constructed an aqueduct more than 200 miles long, running through 142 tunnels, which tapped the Owens River and virtually drained Owens Lake, turning a once fertile part of the southern Sierra Nevadas into a wasteland. In 1913, when he opened the floodgates on this milestone in the engineering and environmental history of the West, Mulholland turned to the assembled dignitaries and said simply, "There it is, gentlemen, take it."

For a brief history of the City of Los Angeles acquiring water see Appendix 1.

In the early years of the Bureau of Reclamation, many projects encountered problems: lands/soils included in projects were unsuitable for irrigation; land speculation sometimes resulted in poor settlement patterns; proposed repayment schedules could not be met by irrigators who had high land preparation and facilities construction costs; settlers were inexperienced in irrigation farming; water logging of irrigable lands required expensive drainage projects; and projects were built in areas which could only grow low-value crops. In 1923 the agency was renamed the "Bureau of Reclamation." Then, in response to increased financial problems, in 1924 Congress approved the "Fact Finder's Report" to resolve the financial and other issues.

In 1928 Congress authorized the Boulder Canyon (Hoover Dam) Project, and large appropriations began to flow to Reclamation from the general funds of the United States. The authorization came only after a hard fought debate about the pros and cons of public power versus private power. This debate stemmed from the millions of dollars made by private investors, similar to William Mulholland who purchased thousands of acres of land and manipulated water resources from properties they didn't even own. Obviously, where this kind of money making potential existed, there would be huge private interests.

Reclamation construction of water facilities began to boom during the Depression and for about thirty-five years after World War II. Hundreds of water projects were initiated without any real geological consultation or knowledge of the repercussion on moving so much water. As part of President Franklin Roosevelt's New Deal a building craze began. Engineers and builders were employed by the thousands in order to help generate money for the economy. However, no scientific or geological input was elicited to determine the consequences of such construction and manipulation to the land and rivers. The last major authorization for construction projects occurred in the late 1960s while a parallel evolution and development of the American environmental movement began to result in strong opposition to water development projects (Rec. Bureau Web Site). The 1976 failure of Teton Dam as it filled for the first time, did not diminish the Bureau' strong international reputation in water development circles even though it may have been one of the worst disasters in United States History. However, this first and only failure of a major Bureau of Reclamation dam did shake the bureau which subsequently developed a very strong dam safety program designed to avoid similar problems in the future. However, the failure of Teton Dam, the environmental movement, and the announcement of President Jimmy Carter's "hit list" on water projects profoundly affected the direction of Reclamation's programs and activities in the United States. Politics took over any real care for the environment when the Bureau of Reclamation became involved in a political battle with the young Army Corps of Engineers. This led to even more dams, bigger dams, and more geologically unstable times—of course, inspired by politics.

If one were to look at a more specific example of the debacle of water politics, the Colorado River, it becomes even clearer of why the US has a water problem.

Over 25 million people are dependent upon water from the Colorado River and 3 million acres of farmland are irrigated from its flow (Pontius, 1997). The water of the Colorado is in very high demand throughout its course, but most especially in the arid Southwest states of California, Arizona, and Nevada. The Law of the River (LOR) is a composite of state and federal laws and regulations along with court decisions and international agreements that governs each user's allocation and priority. The LOR has evolved from a simple allocation of water rights into a legal and institutional chaotic mess of governance of the river and its water.

The Bureau of Reclamation built, operates, and maintains the diversion structures that control use of the Colorado waters. Complete control on these waters lies with the Secretary of the Interior. The Secretary, called Watermaster, can distribute surplus supplies and determine how shortfalls are distributed. Any user of main stem Colorado River water is required to execute a contract for its use with the Secretary and has the authority to define what an allowable "reasonable beneficial use" is. The Secretary attempts to reach consensus with the states, tribes, and other interests but in the event of deadlock, he has the authority to act unilaterally on management issues (Pontius, 1997).

The Law of the River formally began with the Colorado River Compact of 1922. This agreement divided the watershed into three components – the Upper Basin (comprised of Wyoming, Colorado, Utah, New Mexico, and a small segment of Arizona); the Lower Basin (comprised of Arizona, California, and Nevada); and Mexico. The Upper and Lower Basin boundary was marked at Lee Ferry, Arizona. The measured River flow for the 10 years prior to 1922 had averaged 18.8 million acre-feet (maf) per year so the negotiators felt confident in allocating 17.5 maf per year. The Upper and Lower Basin split 15 maf per year in the Compact. Due to the arid nature of the Lower Basin, it would receive an additional 1 million acre-feet if it was available in "wet" years for a total of 8.5 maf annually (Sax et al., 1991). Even in the event of a long-term drought, the Upper Basin is responsible to deliver 75 maf per decade without fail under Article III(d). This means that shortfalls will be shouldered by the Upper Basin unless this article can be rescinded. There are also provisions in the law that guarantee Mexico water, but everyone still seems unsure of where that water would come from in the event of a real long term drought.

The Boulder Canyon Project Act of 1928 authorized the construction of Hoover Dam and the All-American Canal. These structures were very important for implementing the 1922 Compact and beginning large-scale diversions of the Colorado. A minor element of the Boulder Canyon Project

Act was that Congress authorized the negotiation of intra-basin allocations. As a suggested guideline they offered 4.4 maf to California, 2.8 maf to Arizona and .3 maf to Nevada with California and Arizona splitting any surplus. (Nevada was a desert at the time and no one ever expected it would need water, this was also pre-Las Vegas.)

World War Two was beginning to rumble, and Mexico was beginning to impact water flows of the Rio Grande in Texas. International comity with Mexico was crucial with WWII raging and the US needed concessions on the Rio Grande, so 59 Stat. 1219 (the Mexican Water Treaty) was signed. This guaranteed Mexico 1.5 maf per year and stipulated that Mexico could request up to 1.7 maf during a surplus year. Droughts were beginning to occur more frequently along the Colorado watershed, so previsions were made in this treaty for such events. During drought, deliveries to Mexico would be reduced.

Drought has become a far greater concern in negotiations over the LOR as annual flows of the Colorado since the 1922 Compact have average far less than the 17.5 maf needed to satisfy all claims to the water that were originally set up. The average river flow from 1930 to 1996 has been estimated by the Bureau of Reclamation at 13.9 maf. One disturbing factor is that 86% of the Colorado River's flow originates in a small region of the Rocky Mountains, less than 15% of the total watershed (Stockton et al., 1991). A severe drought in this area would have profound ramifications for all users of Colorado River water--another example of the information gap between science and policy makers.

Professor Robert Glennon at the University of Arizona has suggested that the Upper Basin is not bound by the 75 maf per decade requirement. It is an established principle of contract law that if both parties are mistaken about a material fact in a contract, i.e. annual stream flow, then that section of the contract is legally 'removed' from the contract. This principle of mutual mistake allows for the intent of the parties to be followed rather than the actual wording of the contract if it is based upon a faulty premise. The intent of the 1922 Compact would seem to be to split the annual flow between the Upper and Lower Basins. Legally, the Upper Basin could probably force this issue and remove the 75 maf per decade clause, but it would require billions of dollars in legal fees and currently, the Upper Basin has no way to use the water anyway (Mayden, 2000).

Arizona sued California to force an apportionment of the Lower Basin allotment in 1952, and this case finally was decided in 1964 by the Supreme Court. In *Arizona v. California*, the Supreme Court held that in the absence of any other agreements, the apportionment by Congress contained in the Boulder Canyon Project Act had in fact allocated the waters. In a major victory for Arizona, Lower Basin states were allowed to keep complete control over tributaries to the Colorado and deplete them before they reached the main stem of the River, this granted Arizona exclusive use of the 2 maf per year of the Gila River.

The Colorado River Basin Project Act of 1968 gave Arizona a canal to rival the All-American Canal in California. The Central Arizona Project (CAP) allows Arizona's unused allotment to be imported into the southeastern part of the state with a physical capacity of 2 maf per year. The major drawback from Arizona's point of view was that the CAP has the lowest priority in the Lower Basin and in times of drought it would be the first diversion to go dry. The CAP also declared that satisfaction of the Mexican water treaty was a national obligation and directed the Secretary of the Interior to develop criteria for the coordinated long-range operations of federal reservoirs with this requirement in mind. Some have suggested that this prevision overrides the 1922 Compact so that in the case of drought, Mexico's allotment must be found by the federal government from sources beyond the Lower Basin's 7.5 maf (Sax et al, 1991). This is merely an interpretation of the Act that hasn't been addressed by the Courts as yet because there has been no drought severe enough to trigger action. Again, policy makers need an environmental calamity on order to inspire progress in this area.

The final direct component of the Law of the River is Minute 242, a 1973 agreement with Mexico to limit the salinity of water that is delivered in fulfillment of the 1944 treaty. In the 1960's, hypersaline water from the Wellton-Mohawk Irrigation district had been returning to the Colorado River just north of the border and was contaminating fields in Mexicali. Mexicali receives the bulk of Mexico's allocation of Colorado River Water – 1.36 million acre-feet per year. This non-drought affected supply has made Mexicali one of the most productive agricultural areas in Mexico. Minute 242 guaranteed that the water quality for Mexicali is equal to that entering Imperial Valley in the US.

The San Luis Rio Colorado district in Mexico is delivered 140,000 acre feet of water from the Colorado River and is allowed to pump 160,000 acre feet within 5 miles of the border. However, the water delivered via the Colorado River is drainage from the Yuma Valley Division. Minute 242 only provided that this water would remain 'substantially' the same as the water ordinarily delivered there and currently this water has a high salinity index - 1700 PPM before it is mixed with Colorado River water (Furnish and Ladman, 1975).

In order to implement Minute 242, the Colorado River Basin Salinity Control Act of 1974 authorized the construction of the Yuma Desalting Plant, which was completed at a cost of over a billion dollars. Ironically, this was obsolete before it was finished and has never been operated as the Wellton-Mohawk waters are diverted south via canal into the Cienega de Santa Clara and the Colorado River has had adequate freshwater flows to meet the salinity requirements of Minute 242. Operation of the plant to create marketable water has been proposed, but such an action would devastate the ecosystem that has flourished in the Cienega as a result of the agricultural runoff (Glenn et al., 1996).

It is also reasonable to note that the National Environmental Policy Act of 1969 and the Endangered Species Act of 1973 have increasingly come to dominate the LOR even though that was not the expectation when these Acts were authorized. Environmental concerns were not in existence when the majority of the dams were constructed on the Colorado and native wildlife has been devastated. The dams block fish passage, trap silts, curtail spring floods, and dramatically alter water temperatures. Beaches have been eroded and backwater marshes destroyed. There have also been major losses of exotic species of plants and animals.

3. RECENT HISTORY

Currently, Reclamation operates about 180 projects in the 17 Western States. The total Reclamation investment for completed project facilities in September of 1992 was about $11 billion. Reclamation projects provide agricultural, household, and industrial water to about one-third of the population of the American West. About 5 percent of the land area of the West is irrigated, and Reclamation provides water to about one-fifth of that acreage. Reclamation is a major American generator of electricity. In 1993 Reclamation had 56 power plants on-line and generated 34.7 billion kilowatt hours of electricity (Rec. Bureau Web Site).

Between 1988 and 1994, Reclamation underwent major reorganization as construction on projects authorized in the 1960s and earlier drew to an end. The Bureau of Reclamation wrote that "The arid West essentially has been reclaimed. The major rivers have been harnessed and facilities are in place or are being completed to meet the most pressing current water demands and those of the immediate future." Emphasis in Reclamation programs shifted from construction to operation and maintenance of existing facilities. Perhaps the arid West was reclaimed, the water is certainly not wasted, but no one had yet addressed the problem of the water not coming back.

Currently, it seems that not much progress has been made. The Water Resources Development Act of 1999 (WRDA 99) passed unanimously in both the House and Senate on August 5, 1999. The President signed it into law (Public Law 106-53) August 17, 1999. Because it is an authorization law, a WRDA approves projects, studies and programs and authorizes appropriations, but does not appropriate funds. The Congressional Budget Office estimates that if the entire act were funded, the total cost would be $6.1 billion, with $4.2 billion as the federal share and $1.9 billion in non-federal funds.

WRDA 99 authorizes 45 projects in 19 states and Puerto Rico. If funded, these projects would cost an estimated $1.41 billion in federal money and $880 million in non-federal funds, for a cost-shared total of $2.3 billion. They are, by state or territory:

- Alaska - Nome Harbor improvements, Sand Point Harbor, Seward Harbor, Heritage Harbor;
- Arizona - Rio Salado in Phoenix and Tempe, Tucson Drainage Area;
- California - American and Sacramento Rivers, Oakland Harbor, South Sacramento County Streams, Upper Guadalupe River, Yuba River Basin, Hamilton Airfield, Success Dam in the Tule River Basin;
- Delaware - Delaware Bay Coastline: Broadkill Beach, Port Mahon, Roosevelt Inlet-Lewes Beach; Delaware Coast from Cape Henelopen to Fenwick Island, Bethany Beach/South Bethany Beach;
- Florida - Hillsboro and Okeechobee Aquifer, Jacksonville Harbor, Tampa Harbor - Big Bend Channel, Little Talbot Island in Duval County, Ponce de Leon Inlet;
- Georgia - Brunswick Harbor, Savannah Harbor expansion;
- Illinois - Des Plaines River;
- Kansas - Turkey Creek Basin, Kansas City;
- Kentucky - Beargrass Creek, Reelfoot Lake;
- Louisiana - Amite River and Tributaries, East Baton Rouge Parish Watershed;
- Maryland - Baltimore Harbor anchorages and channels;
- Missouri - Turkey Creek Basin, Kansas City;
- New Jersey - Delaware Bay Coastline: Villas and vicinity, Oakwood Beach, Reeds Beach and Pierces Point; Townsends Inlet to Cape May Inlet, Brigatine Inlet to Great Egg Harbor at Brigadine Island;
- Oregon - Columbia River Channel;
- Puerto Rico - Guanajibo River, Rio Grande de Manati in Barceloneta, Rio Nigua in Salinas;
- Texas - Salt Creek in Graham, Johnson Creek in Arlington;
- Virginia - Baltimore Harbor anchorages and channels;
- Washington - Columbia River Channel, Howard Hanson Dam.

However, these projects did not receive any sort of funding because of the scarce resources that our government is working with plus the different priorities our government is working with. The attention of the government is more focused on current issues like defense and health care, rather than the long term effects of water projects. Diane Raines Ward lays out the problem in this manner:

> We can no longer afford foolishness. We are using our supplies of clean fresh water at a rate outpacing population growth. How well we manage the water we have is becoming a matter of life and death more quickly than we are prepared for. As pressure increases, the decisions we make need to be good ones. It's important to understand what works, and what does not and why.

This thesis will attempt to answer the question of why, with all of the understanding of the history of the US Western water supply, the current scientific knowledge of how to fix the problems and society willing to learn about and practice water conservation, the problem of water running out is still a concern and perhaps even getting worse.

4. CONFUSION-REASONS FOR NOT FIXING THE PROBLEM

One can be easily confused after reading a lot of scientific data and opinions. There are many mixed messages being conveyed about a lot of different things, especially in science. Before politicians take too much of the blame for not fixing all of our environmental problems, especially ones that deal with scientific principles, it is helpful to note some of the skeptics to our environmental meltdown. Bjorn Lomborg, author of *The Skeptical Environmentalist* tells society the human impact on the environment is not as bad as we think and there is factual data that completely negates societies four big environmental fears of natural resources running out, uncontrolled population growth, loss of biodiversity, and over pollution. According to an article by Bjorn Lomborg in the *Economist*, we have more natural resources than we think, we are producing more food per person, 52% more, since 1961, and people who are starving dropped from 45% in 1949 to 18% today. Lomborg says the threat of biodiversity loss is exaggerated because of faulty inaccurate experiments and, finally, the pollution problem is also exaggerated because new data shows that once a society becomes rich enough to afford to be concerned about the environment air pollution diminishes. London for example, peaked in air pollution in 1890, today; London has its cleanest air since 1585, ignoring the 1952 London Fog which killed 4,000 inhabitants. Lomborg thinks that society sees everything in such a pessimistic view because our media exploits everything in such a negative light. People are much more interested in terrible news than good news, so everything concerning the environment that is somewhat harmful gets exaggerated. A good example of this was the issue of El Nino in 1997 and 1998. The world saw this weather occurrence as the beginning of the end of mankind-- blamed for 22 deaths in Ohio, wrecked tourism, and caused allergies. However, according to Lomborg, El Nino actually saved the world more money and kept more people alive because it caused higher winter temperatures, which were estimated to have saved 850 people's lives. It also kept spring floods to a minimum and even kept hurricanes to a minimum that saved millions of dollars. These things were *not* reported.

So there is believable and factual evidence that many of our problems are exaggerated. Thus, policy makers are obviously not going to be very supportive of spending billions of dollars to fix problems such as the water shortage.

Another point of confusion for people unfamiliar with the scientific world, specifically, geology, is the time scale that geologists work at which relates to water. Geology deals with a very large time scale--it is almost incomprehensible for the public at large to grasp. Not many people can understand what is meant by the Earth being 4.5 billion years old; that the dinosaurs ruled our planet 65 million years ago; that a major percentage of our livable land was sheeted in hundreds of feet of ice only 15,000 years ago.

The average person only lives about 70 years. On the geologic time scale, that is hardly worth noting. Humans don't realize how insignificant in time our presence on this planet really is. Environmentalists are certainly right in saying that some of our practices are hurtful, but who are they hurtful to--clearly, not the Earth. It is safe to say that no matter what awful activities humans inspire as far as hurting the environment, geology and the mechanics of the Earth will prevail in the long run. In a couple 100 million years, our presence on this planet will not even be remembered or seen since the plates will have moved around, some may have been subducted and melted and a new environment will have surely been created. It may be true that we as humans will have killed ourselves because of our poor environmental practices, but it is wrong to say that we are hurting the planet, we are only hurting ourselves. And this doesn't give credence to the stress we put on ourselves or the environment, but it certainly should make us think twice about what repercussions our environmental activities may have on our relatively short time here on this planet. So, when a politician hears that there will be a drastic environmental catastrophe in the next two years he or she is more likely to be concerned and spring to action then if he or she hears the catastrophe will occur in the next century.

5. ECONOMICS AND POLITICS FACTORING IN

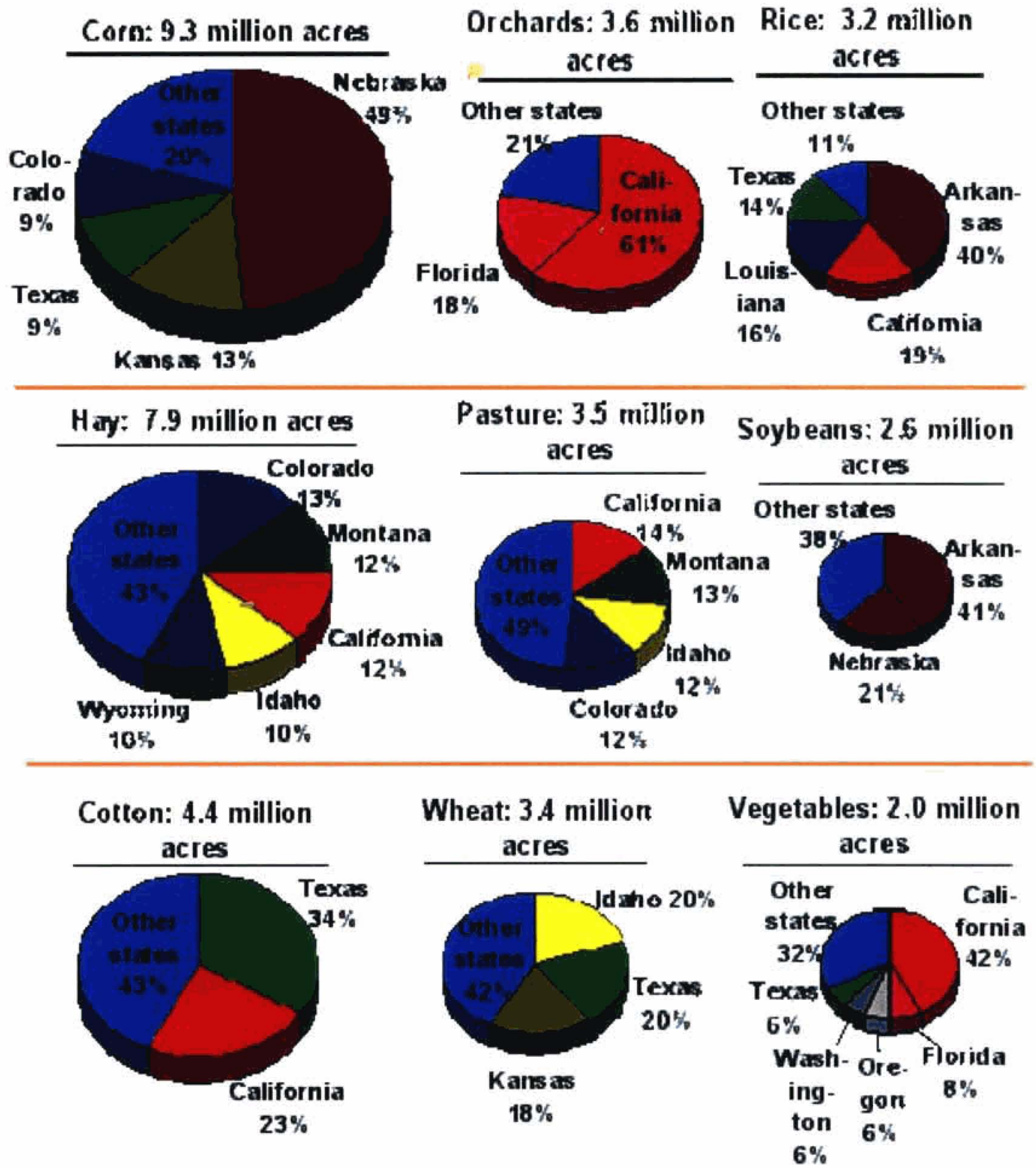
We must discuss money and economics in figuring out why policy makers are not following through with grand plans to fix the western water shortage.

Irrigated Agriculture and related industries--agricultural services and food processing--serve as the nation's "quiet industry," steadily and reliably producing tens-of-billions of dollars worth of state and regional income. The industry affects almost all economic sectors of the western states' economy, purchasing billions of dollars of good and services. They host about 34 million acres of irrigated croplands composed of private irrigators using water pumped from rivers and reservoirs, irrigators served by the US Bureau of Reclamation projects and irrigators pumping from deep or shallow wells.

This irrigation activity creates an annual farm-gate production value exceeding $31 billion. The growing of fruit and vegetables, alone, represents a $15 billion annual production industry. From the irrigated agriculture industry, the US exports about $10 billion annually in commodities and value-added products (Olsen, 2000). The following graphic illustrates the amount of irrigation used to fuel specific crops and the percentage of crops grown in each state. See figure 2.

Figure 2.

Number of acres irrigated, by crop type, in the U.S. in 1994



Working its way through state and regional economies, agricultural production creates about $60 billion in annual income, the bulk of which can be attributed to Western irrigation production. In Washington State, agricultural production creates about $6 billion in annual income. The Columbia Basin Project, with its half-million irrigated acres, generates locally about $800 million dollars annually in direct and secondary income benefits. Overall, the irrigated agriculture industry--consisting of the direct agriculture production sector, agricultural services, and the food processing sector--is one of the largest employers in the West.

Moreover, Western irrigated agriculture is an efficiency success story, reflecting careful use of water resources. For the past thirty years irrigated agriculture has substantially increased production per acre for all crops while decreasing water use per acre.

Today, the number one agricultural issue for federal and state policy decision-makers should be maintaining the country's present standard for low-cost, 24-hours-a-day (every day) accessible, high-quality food products--particularly the fruits, vegetables, and processed food products made available by Western irrigated agriculture (Olsen, 2000).

Obviously, in the West, irrigated lands provide the stimulus for the economy. How then, can any politician with any desire to become re-elected challenge the irrigation policies of the agricultural community even though the practice may be detrimental to maintaining a livable environment for the west? The Family Farm Alliance web site contains this statement, "So the next time you pick up a package of carrots or bag of apples at the store, bear in mind that it represents billions of dollars of economic income and prosperity, and while contributing to a quality of life that is envied throughout the world. The [farming industry] makes a significant difference to our well-being and should not be taken for granted." The question that must be asked is should water resources be taken for granted just so we can keep producing an exorbitant amount of food that generally gets wasted? According to a 1997 study by US Department of Agriculture's Economic Research Service (ERS) entitled "Estimating and Addressing America's Food Losses", about 96

billion pounds of food, or more than a quarter of the 356 billion pounds of edible food available for human consumption in the United States, was lost to human use by food retailers, consumers, and foodservice establishments in 1995. Fresh fruits and vegetables, fluid milk, grain products, and sweeteners (mostly sugar and high-fructose corn syrup) accounted for two-thirds of the losses. 16 billion pounds of milk and 14 billion pounds of grain products are also included in this loss. These products are some of the largest agricultural products produced. Given this information, it seems we could stand to implement some more efficient irrigation policies, saving millions of gallons of water, with the tradeoff of producing slightly less food.

This table can help explain why politicians would be pressured not to disrupt any irrigation practices by western farmers. Again, consider the amount of money involved in this business and how much any change would affect the American economy. See Table 1.

Table 1.

State and Regional Economic Impacts

Another way to understand the effects of agriculture and irrigated agriculture on the state and regional economy is to estimate the "flow" of purchases and sales between the agricultural industry and other economic sectors. This is sometimes referred to as quantifying the "linkages" between the major industries and economic sectors.

Agriculture and Irrigated Agriculture
Estimated Economic Impacts to Other Economic Sectors
(x 1,000,000 1994$)

	California			Idaho		
Major Economic Sectors	Ag. Prod. Buying	Ag. Prod. Selling	Food Process. Buying	Ag. Prod. Buying	Ag. Prod. Selling	Food Process. Buying
Agricultural Production	$896	$896	$3,828	$112	$112	$622
Ag. Services & Forestry	$2,245	$339	$3	$58	$12	$1
Mining	$2	$1	$11	$0	$0	$3
Construction	$100	$2	$145	$9	$2	$15
Food Processing	$144	$3,828	$2,368	$4	$622	$196
Lumber & Wood Products	$84	$6	$5	$1	$2	$1
Pulp and Paper Mfg.	$87	$1	$797	$1	$1	$38
Chemical and Allied Prods.	$153	$19	$128	$16	$1	$7
Fabricated Metal Products	$4	$1	$345	$1	$0	$3
Machinery & Equipment	$57	$1	$32	$4	$1	$3
Railroad and Related Serv.	$35	$1	$103	$4	$0	$10
Freight Transport and Wareh.	$247	$8	$777	$19	$5	$111
Water Transportation	$8	$0	$53	NA	$0	$2
Air Transportation	$20	$0	$32	$1	$0	$2
Transportation Service	$4	$0	$12	$1	$0	$1
Communications	$24	$0	$277	$1	$0	$25
Utilities	$131	$0	$338	$5	$0	$29
Wholesale Trade	$694	$3	$2,600	$27	$1	$200
Retail Trade	$47	$203	$33	$4	$7	$3
Financial Institutions	$174	$2	$175	$10	$1	$8
Real Estate	$546	$7	$114	$38	$0	$8
Personal Services	$1	$0	$14	$1	$0	$1
Business Services	$13	$0	$497	$1	$0	$23
Repair and Automotive Serv.	$68	$0	$60	$4	$0	$4
Consulting and Research	$16	$2	$150	$1	$0	$4
Other Sectors	$201	$51	$1,450	NA	$2	$42
Total:	**$6,001**	**$5,371**	**$14,347**	**$323**	**$769**	**$1,362**
		Selling	Selling		Selling	Selling
Domestic Export		$17,206	$22,324		$1,812	$2,748
Foreign Export		$2,826	$2,377		$261	$320
Local Consumption		$3,133	$13,413		$126	$386
Local Intermediate Demand		$5,371	$5,376		$769	$304
Total Value		**$28,536**	**$43,490**		**$2,968**	**$3,758**

Primary Data Sources: IMPLAN Data Base and U.S. Dept. of Commerce, REIS Data Base

Given the billions of dollars this industry generates, one can see that getting 11 million dollars from the 2004 Federal Budget will hardly be enough to make a real impact on the problem. Secretary of the Interior Gale Norton and the Bush Administration must be realistic about how much money is involved in this economic problem and be more generous with supporting a restructuring with federal dollars—if they really want to be helpful.

6. ILLOGICAL PRACTICES

One can also look at the state of Utah to help understand why there is differing opinions about the water shortage. To some, Utah is the next up and coming state to live and raise a family in. To others, it is a state that will be unable to sustain any sort of population at all. As an elevated desert, average elevation of the state is about 6200 feet, Utah is home to a relatively small population, but it is steadily increasing. Utah happens to be a member of the a group of Western states who's populations are dramatically increasing even though water supply to these states in dramatically decreasing. These states include Arizona, California, Nevada, and New Mexico. All of these states, save Northern California, are at risk of losing a constant water supply and being unable to sustain their ever increasing population.

These three figures (figure 3, figure 4, and figure 5 from the Water 2025 Web Site) show the illogical phenomena of states that are in the middle of a deadly drought, over pumping their groundwater supplies and, ironically growing faster than any other state in America. Imagine all three of these figures overlapping. An area in the west exists where drought conditions, over pumping groundwater conditions, and huge population increases are colliding.

Figure 3.

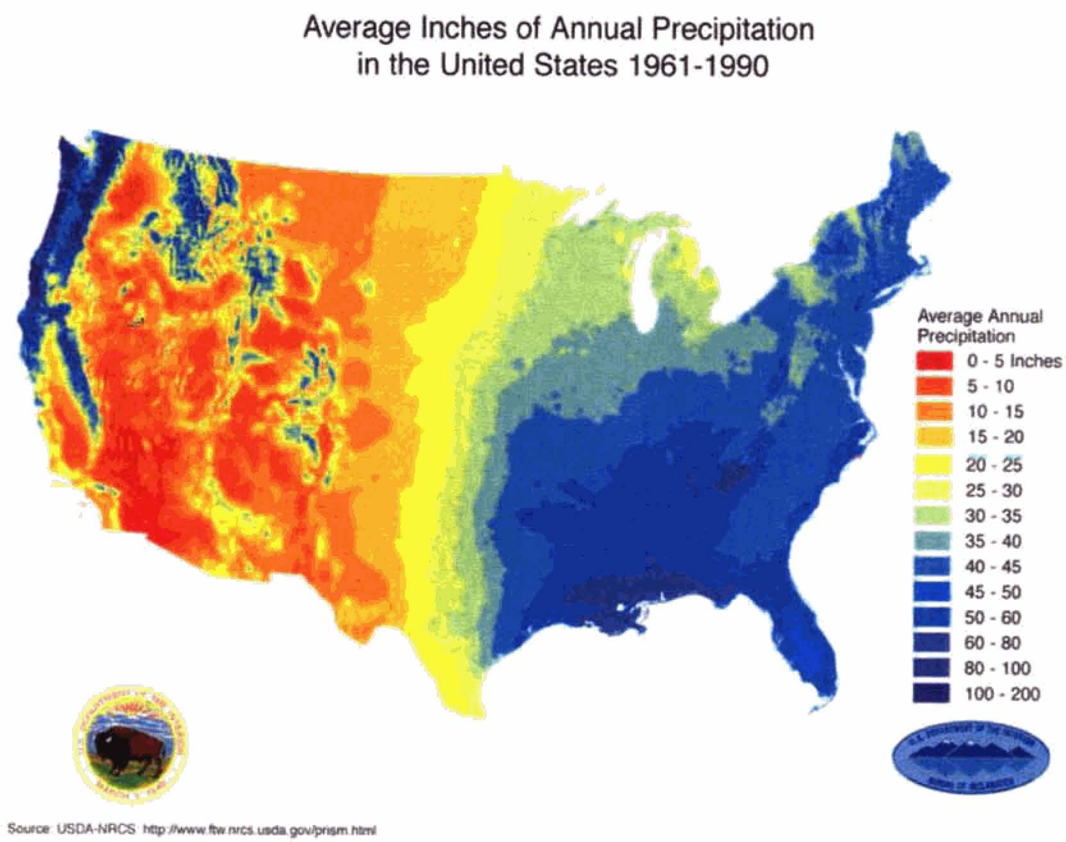

Average Inches of Annual Precipitation
in the United States 1961-1990
Average Annual Precipitation
0 - 5 Inches
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 60
60 - 80
80 - 100
100 - 200
Source: USDA-NRCS http://www.ftw.nrcs.usda.gov/prism.html

Figure 4.

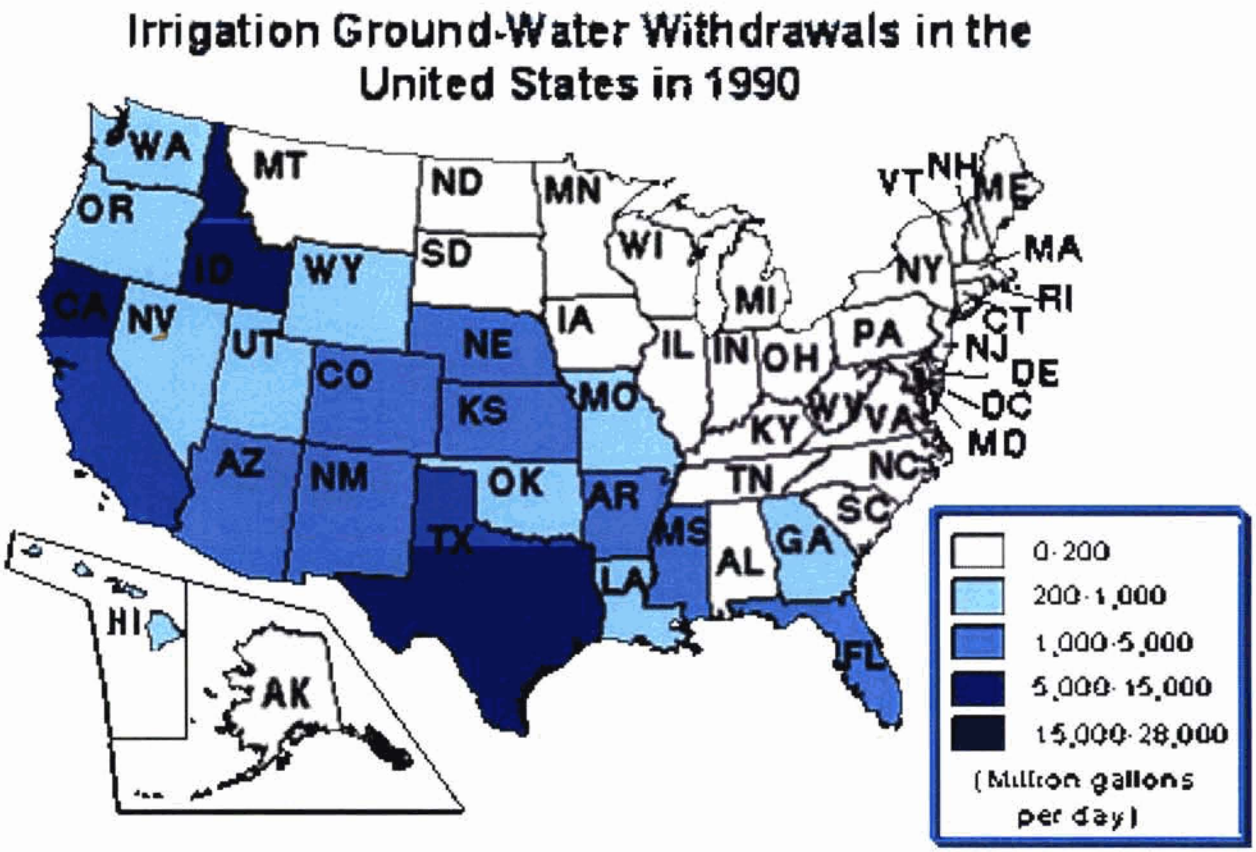
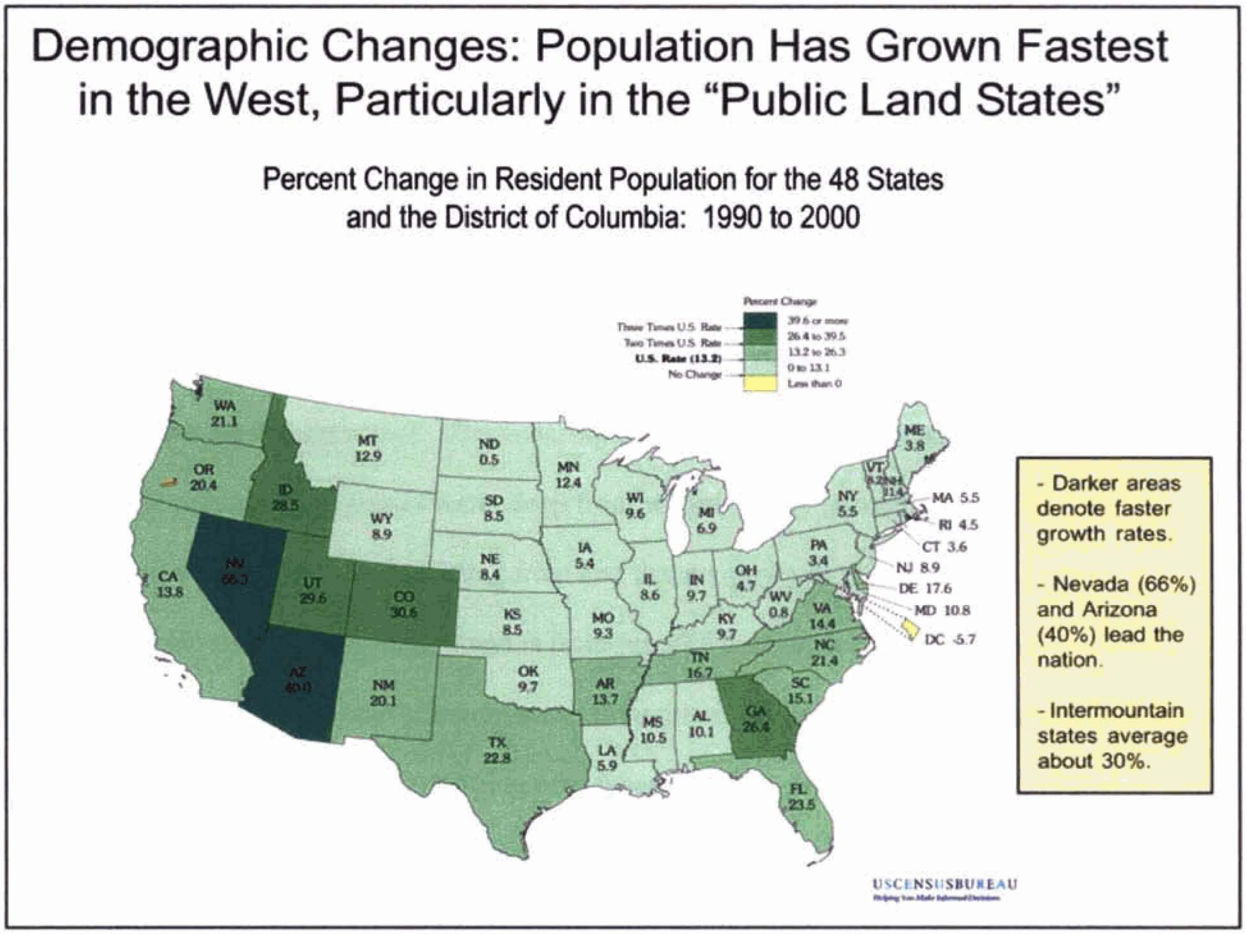

Irrigation Ground-Water Withdrawals in the United States in 1990
WA
MT
ND
MN
VT
NH
ME
OR
WI
MA
ID
WY
SD
NY
CA
MI
RI
NV
IA
PA
CT
UT
NE
IL
IN
OH
NJ
CO
DE
KS
MO
WV
VA
DC
KY
MD
AZ
NM
OK
TN
NC
AR
SC
TX
MS
GA
AL
LA
HI
AK
FL
0-200
200-1,000
1,000-5,000
5,000-15,000
15,000-28,000
(Million gallons per day)

Figure 5.


Demographic Changes: Population Has Grown Fastest in the West, Particularly in the "Public Land States"
Percent Change in Resident Population for the 48 States and the District of Columbia: 1990 to 2000
Percent Change
Three Times U.S. Rate
Two Times U.S. Rate
U.S. Rate (13.2)
No Change
39.6 or more
26.4 to 39.5
13.2 to 26.3
0 to 13.1
Less than 0
WA 21.1
OR 20.4
CA 13.8
ID 28.5
NV 66.3
MT 12.9
WY 8.9
UT 29.6
AZ 40.0
CO 30.6
NM 20.1
ND 0.5
SD 8.5
NE 8.4
KS 8.5
OK 9.7
TX 22.8
MN 12.4
IA 5.4
MO 9.3
AR 13.7
LA 5.9
WI 9.6
IL 8.6
MS 10.5
MI 6.9
IN 9.7
KY 9.7
TN 16.7
AL 10.1
OH 4.7
WV 0.8
GA 26.4
FL 23.5
SC 15.1
NC 21.4
VA 14.4
PA 3.4
NY 5.5
ME 3.8
MA 5.5
RI 4.5
CT 3.6
NJ 8.9
DE 17.6
MD 10.8
DC -5.7
- Darker areas denote faster growth rates.
- Nevada (66%) and Arizona (40%) lead the nation.
- Intermountain states average about 30%.
USCENSUSBUREAU

Hiking along Sanpete Valley in Central Utah one is exposed to the problem of living in these states first hand. July 2003 was Utah's hottest July on record, or at least since 1904 when temperature records were recorded. It had the most consecutive days above one hundred degrees. Along the Wasatch and Gunnison Plateaus the slopes are covered in dry mud, scrub brush and juniper trees, perfect items for a desert environment. What also makes the slopes of Sanpete valley unique is the large amount of free range cattle, sheep and other animals that are wandering around grazing on the already barren land. Their presence is preserved in the many skeletons and carcasses strewn about the land...indicating their inability to survive the harsh elements. Perhaps this is a small sign of the inevitable.

The other sight that is breathtaking is the green valley floors peppered with behemoth irrigation equipment and sprinklers. The watering devices seem to never sleep. They are pumping hundreds of thousands of gallons of water deep from within the dry ground from dawn until dusk. Some may ask where this water is coming from and the answers will vary. Some is from deep groundwater below the valley floor. Some is from runoff from the plateau, some from reservoirs, some from the dying and drying Colorado, some from other states. This is one of the many problems in the West, many communities are fighting over where they are getting their water and who is really belongs too. People are beginning to realize that in an arid climate water is not a renewable resource and they are buckling down on who gets the water and where it is coming from.

7. WATER WARS

The water wars in the west are just beginning to become a real national issue. Mark Twain captured the West's tension over water with his famous quip that "whiskey's for drinking, water's for fighting about." Sandra Postel, director of the Global Water Policy Project writes that one-fifth of the Colorado River's annual flow goes to the Imperial Irrigation District (IID), which irrigates nearly 534,000 acres of cropland. Because of a century-old deal with the Federal government, IID gets this water free. Farmers within the district pay just for the cost of delivering the water, about one cent per cubic meter, roughly 30 cubic feet or one thirtieth of a cent per cubic foot. A few hundred miles to the west in Los Angeles, the Metropolitan Water District (MWD), the water wholesaler for about 16,000,000 southern Californians, pays up to 16 cents per cubic meter (1/2 cent per cubic foot) for water that it sells to its customers for about 28 cents a cubic meter (1 cent per cubic foot)--28 times as much as the IID farmers pay (Postel, 2000).

In the western U.S., the city-farm competition, or war, is heating up. Cities are buying water, water rights, or land that comes with water rights in parts of Arizona, California, Colorado, and elsewhere. The biggest trades so far have involved the Imperial Irrigation District in southern California.

In addition to the recent deal with San Diego, IID agreed to a trade in 1989 with the Metropolitan Water District in Los Angeles. MWD agreed to invest in efficiency improvements within IID in exchange for the water those investments save. The trade will shift up to 106,000 acre-feet (130,800,000 cubic meters) a year from farm to urban uses for 35 years. MWD benefits because the cost of the conserved water will be less than 10 cents per cubic meter, much lower than its best new-supply option. IID benefits from the cash payments and an upgraded irrigation network. Because the water traded is generated through conservation, no cropland needs to come out of production.

Another MWD deal, though, does require farmers to take land out of irrigated production. In 1992, the urban water wholesaler entered into an agreement with the Palo Verde Irrigation District, located on the west side of the Colorado River between Parker and Imperial dams. The agreement called for Palo Verde farmers to let a portion of their cropland lie fallow for two years and transfer the resulting water savings to MWD.

Facing unstable crop prices, 63 farmers signed on, following a total of 8,181 hectares. MWD paid the irrigators $3,064 for each hectare left unplanted and, in return, received a total of 228,000,000 cubic meters of water--the equivalent of about 10% of MWD's yearly deliveries. The transferred water was stored in Federal reservoirs on the lower Colorado River for use any time MWD desired before the year 2000. And in its deal with IID, MWD benefited by obtaining additional supplies at a lower cost. Palo Verde farmers benefited from more stable income. However, because land was taken out of production, farm workers lost jobs (Postel, 2000).

Water transfers often affect people not involved directly in the sale, which makes a full accounting of costs and benefits hard to achieve. The costs to so-called third parties, who rarely have a place at the negotiating table, can be substantial. These can also be cumulative, affecting rural communities, employment, the tax base, and the environment. Because poorer farm laborers may be the ones to lose jobs, even economically efficient water trades may worsen inequities. Water trades can damage downstream wetlands and lakes, IID's deals with the MWD and San Diego, for example, could harm the inland Salton Sea, an important stopover for many species of migratory birds. Though polluted, IID's drainage is critical to sustaining the area and the quality of the sea, which is already 25% saltier than the Pacific Ocean. As IID sends increasing amounts of its water to southern California cities, the sea will shrink and become even saltier.

In sum, the limited evidence to date suggests that the impacts of water transfers are decidedly mixed, complex, and difficult to predict. Without a doubt, cities will continue to siphon water away from agriculture. What is not known is how much ultimately will be reallocated and how great an impact that will have on food production, farmers, and rural economies. Unless this competition is managed well, it could dampen food supplies in some areas, while making the rich richer and the poor poorer. An additional problem is the probability that competition for water may force more rural dwellers to head for the cities--which, in a vicious circle, would intensify the situation. Again, politics will play the most important role in fixing the problem. Obviously, these wars will help decrease the amount of water available for consumption. But, politicians will have a difficult time deciding what to do, if anything, because of the interests involved. The farmers are a powerful group, but so are the urban cities.

On a more global scale war with water in ever-decreasing supply, the forces of the marketplace are positioning themselves to profit from the demand. Because Canada's lakes and rivers hold approximately one-quarter of the Earth's fresh water, global entrepreneurs are vying to ship billions of liters of Canadian water to customers in California, Mexico, Japan and the Middle East (Smith, 2000).

Several US companies already have laid claim to Canada's water under the North American Free Trade Agreement (NAFTA) and they have threatened legal action through the World Trade Organization if their plans are blocked (Smith, 2000).

8. THE MEDIA PLAYING A ROLE

After careful review of the *Salt Lake Tribune*, Utah's largest newspaper, one can certainly obtain a mixed message about the water conditions of the state and the real risk the residents are at. The following headlines appeared in the paper, respectively: "Utah still worst drought state"; "Hit hard by drought, state parks may be closing"; "Water users suck ponds dry in Hyrum"; "Drought-spawned moss clogs the pipes"; "St. George, Logan now 'metropolitan.'"

Each of the first four articles paints a dim picture of the current environment in Utah. They basically say the state is completely running out of water and there is nothing anyone can do about it unless drastic measures are taken to ration water or generate massive amount of precipitation. Again, this is not that untypical of a desert environment which is Utah. But the problem is that millions of people live in this desert and they want water. The ironic part about this list of headlines is the last one, "George, Logan now 'metropolitan.'" This was an article touting the new designation of Utah's driest most drought ridden southwest area with an average temperature of 103 degrees during the summer as one of the fastest growing areas in the state. Logically this simply does not make sense. Why does a state like Utah, in its current conditions attract so many people? Western society obviously does not yet understand the impending water crisis and again, no one is doing anything productive to let them know. Instead of the media markets publicizing Utah as a great place to live, perhaps people would be better served if there was an organized effort to educate people on reality and help water conservation efforts.

9. GEOLOGIC CONSEQUENCES

It is also helpful to understand the geological consequences of abusing our water resources. One of the most prevalent issues surrounding abusive groundwater withdrawal is the occurrence of land subsidence. As aquifers are drained of their water, it causes a tremendous pressure relieve from the pore spaces in the rock units that once held that water. As water is pumped out and the pressure leaves, the empty pore spaces in the rock will begin to compress. This will cause a subtle or sometimes drastic land subsidence. Florida for example has had catastrophic sink holes develop because of land subsidence. Holes ranging from a few meters to hundreds of meters can develop overnight. See Appendix 2 for land subsidence pictures (www.usgs.gov).

Other problems occur when rivers and streams are dammed and redirected. There have been countless examples of dam failures like the Teton or Johnstown, PA flood. There are many cases of dams filling with silt, then failing, washing out towns.

Many rivers will be redirected by man only to find their original path again no matter what man made obstacle stands in its way. In examples like the Alamo River continually jumping back and forth to create the Salton Sink or the Salton Sea (depending on how much precipitation occurs), man alone could not stop it. Even in places like Columbus, OH, engineers moved the Olentangy River to build Ohio Stadium and currently, engineers have installed an elaborate pumping system to remove flood waters form the football field every time it rains. The water even makes it underground (and at times to the surface across High St.) towards the central part of the Ohio State University's campus when precipitation is particularly heavy. Rest assured--the Olentangy will eventually reclaim its original flood plain.

And probably the most drastic consequence of water supply manipulation without regard for geological constraint has been the Colorado River drying up.

Currently, the Colorado River barely has enough water left in it to cross the Mexico-United States Border. So many billions of gallons of water have been diverted out of the Colorado up stream that the river has become dry far before it reaches the Pacific.

These accounts are just scratching the surface as to what hydrogeological nightmares can be created by taking water from places where it can't be replaced. This doesn't even count the detrimental affects on other environmental aspects of poor water management: killing populations of fish, plants, wildlife; dislocation of North American Indian tribes, as well as modern urban developments, and the destruction of the beautiful scenery that nature provides for naturalists and recreation enthusiasts.

10. CONCLUSION

After taking a broad look at the ways policy makers and typical citizens in general can become confused and receive mixed messages about the real state of the water crisis it is no wonder why the United States does not have an all encompassing program underway to deal with the future. We can not count on the states to fix their own problems because of the already litigious water wars, and we can't count of the media to really emphasize the idea of water resource conservation rather than ideal places to live, so all things point to the western United States running out of water in the next 25 years—especially with the mass exodus of people to the region and the population growth of the west.

The solution unfortunately is not a quantitative or strategic one. As one can see from the massive amount of water data, history, and current conditions of our water supplies, we know how to fix the problem, we know where the problem is, and we can make the money available. However, the leadership to make it happen is not present. It is easy for policy makers and politicians to ignore the problem when they are helped by a naïve society and media. What needs to happen is simply leadership. A governor, a representative, senator, businessman needs to stop living in the moment or the past and think about what kind of future they want the western United States to have in regards to water resources. Then, if they choose to want to save it they have at their disposal a wealth of information that will tell them how to do so. We can only hope that the people of the west, scientists and others with some sort of clue as to what really is going on can make a stand and help our government understand that we are well into an environmental crisis and must save our water.

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Appendix 1

Los Angeles Water History

- Owens Valley and it's lake at an elevation of 4,000 ft and Los Angeles at an elevation a few feet above sea level. Water could arrive under its own power (no pumping or electricity needed) through aqueducts and siphons (over small mountains) to Los Angeles from Owens.

- 1913 Los Angeles aqueduct constructed – 233 miles long, finished within budget and provides four times as much water needed by LA

- Excess water used to irrigate orchards of San Fernando Valley

- LA expands landholdings in Owens Valley in anticipation of further growth in population 1920s drought - Owens Valley water wars, dynamiting of aqueduct

- Eventually, LA purchased most of land and water rights in Owens Valley led to exporting most of runoff from watershed as well as the groundwater

- Drought in 1920s led to more water shortages. Additional water sources needed

- 1924 LA establishes a consortium of water districts (Metropolitan Water District) to tap into the Colorado River

- Colorado River aqueduct approved in 1928, completed in 1941

- 1940 LA aqueduct extended 105 miles north to Mono Basin

- Second aqueduct to carry more water from Owen's Vally constructed in 1970

1950-1970

- Increased population growth onto floodplains
- Increased flood control measures
- Feather River Project – construction of Oroville Dam
- State Water Project (SWP) – 444 mile long California aqueduct provides water diversions from north to south
- Lots of dams and channels
- Increased logging and aggregate mining

1970-present

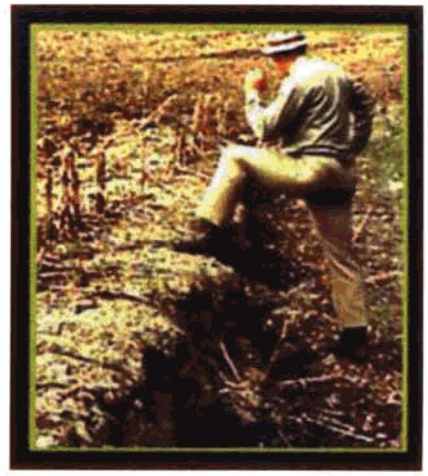
- Dam building decreases – all good sites taken, lack of need for economic development, increased cost for dams and rise of environmental movement
- Sacramento/San Joaquin Delta in a state of decline – loss of species and decreased water quality
- 1982 Peripheral Canal vote defeated

- would have been a 43-mile, dirt-lined canal taking water directly from the Sacramento River and transport it around the Sacramento-San Joaquin Delta to export pumps for shipment south via the California aqueduct

1992 Central Valley Project Improvement Act (CVPIA) passed

- Allocated more water to fish restoration and wetlands enhancement
- Agricultural water users can now sell their water to a city outside the CVP service area

Appendix 2



Above: A farmer struggling with a field that has become unworkable because of land subsidence
Left: Another example of how great an impact pumping the groundwater can have on surface elevation.

Left: A sinkhole. Another repercussion of over pumping the local aquifer.

All graphics courtesy of The United States Geological Survey
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